

## PATENT COOPERATION TREATY

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

United States Patent and Trademark  
Office  
(Box PCT)  
Washington D.C. 20231  
United States of America

in its capacity as elected Office

<b>Date of mailing</b> (day/month/year) 19 December 1995 (19.12.95)	
<b>International application No.</b> PCT/SE95/00479	<b>Applicant's or agent's file reference</b> 2956122
<b>International filing date</b> (day/month/year) 02 May 1995 (02.05.95)	<b>Priority date</b> (day/month/year) 06 May 1994 (06.05.94)
<b>Applicant</b> HEED, Björn	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

05 December 1995 (05.12.95)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

<b>The International Bureau of WIPO</b> 34, chemin des Colombettes 1211 Geneva 20, Switzerland	<b>Authorized officer</b> F. Gateau
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 730.91.11

## PATENT COOPERATION TREATY

## PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

REC'D 22 AUG 1996

WIPO PCT

Applicant's or agent's file reference 2956122	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/SE95/00479	International filing date (day/month/year) 02.05.1995	Priority date (day/month/year) 06.05.1994
International Patent Classification (IPC) or national classification and IPC <sub>6</sub> F28D 9/00, B21D 53/04		
Applicant Heed, Björn		

<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of <u>3</u> sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of <u>2</u> sheets.</p>
<p>3. This report contains indications relating to the following items:</p> <p>I <input checked="" type="checkbox"/> Basis of the report</p> <p>II <input type="checkbox"/> Priority</p> <p>III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p>IV <input type="checkbox"/> Lack of unity of invention</p> <p>V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p>VI <input type="checkbox"/> Certain documents cited</p> <p>VII <input type="checkbox"/> Certain defects in the international application</p> <p>VIII <input type="checkbox"/> Certain observations on the international application</p>

Date of submission of the demand  05.12.1995	Date of completion of this report  16.08.1996
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Telex 17978 PATOREG-S	Authorized officer  Magnus Thorén Telephone No. 08-782 25 00
Facsimile No. 08-667 72 88	

Form PCT/IPEA/409 (cover sheet) (January 1994)

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE95/00479

**I. Basis of the report**

1. This report has been drawn on the basis of *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.)*:

- ☐ the international application as originally filed.
- ☒ the description, pages 1-7, as originally filed,  
pages \_\_\_\_\_, filed with the demand,  
pages \_\_\_\_\_, filed with the letter of \_\_\_\_\_,  
pages \_\_\_\_\_, filed with the letter of \_\_\_\_\_.
- ☒ the claims, Nos. \_\_\_\_\_, as originally filed,  
Nos. \_\_\_\_\_, as amended under Article 19,  
Nos. \_\_\_\_\_, filed with the demand,  
Nos. 1-3, filed with the letter of 18.06.1996,  
Nos. \_\_\_\_\_, filed with the letter of \_\_\_\_\_.
- ☒ the drawings, sheets/fig 1-4, as originally filed,  
sheets/fig \_\_\_\_\_, filed with the demand  
sheets/fig \_\_\_\_\_, filed with the letter of \_\_\_\_\_,  
sheets/fig \_\_\_\_\_, filed with the letter of \_\_\_\_\_.

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages \_\_\_\_\_
- ☐ the claims, Nos. \_\_\_\_\_
- ☐ the drawings, sheets/fig \_\_\_\_\_

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the supplemental Box (Rule 70.2(c)).

4. Additional observations, if necessary:

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE95/00479

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement****1. Statement**

Novelty (N)	Claims	<u>1-3</u>	YES
	Claims		NO
Inventive step (IS)	Claims	<u>1-3</u>	YES
	Claims		NO
Industrial applicability (IA)	Claims	<u>1-3</u>	YES
	Claims		NO

**2. Citations and explanations**

Amended claims have been issued.

The present invention relates to a heat exchanger made of a folded sheet and sealed in order to obtain two separate channels and forming a package. The sheet is corrugated at an angle and the corrugation is interrupted at intervals to facilitate the folding. The package is adapted to be disposed in a casing and the seals are arranged to seal between package and casing.

Prior state of the art well known technology includes folding a sheet to form a heat exchange package. Naturally the channels for the two media have to be separated. However, to use the same seal for both sealing in the package as in the casing is not revealed in the cited documents and cannot be considered obvious to a person skilled in the art.

Hence, the invention is novel and not obvious. The invention is industrially applicable.

Do NOT FILE THESE  
CLAIMS - BUT DO  
FILE 3 CLAIMS  
AMENDED IN PCT  
ON 18 JUNE 1996

## CLAIMS

1. A recuperative heat exchanger for the exchange of  
5 heat between two media across a heat-transferring wall,  
c h a r a c t e r i z e d in that:

a) the media separating a heat transferring wall is  
made from a shaped patterned sheet which is repeatedly  
folded to form a multi-layered package which is enclosed  
10 in an outer casing (15, 21; 28, 34, 35);

b) owing to its shaping after folding the sheet forms  
a package (10, 12) of alternating flow channels having  
connecting ports (22-25; 29-32) for the two media on the  
two opposite sides of the package; and

15 c) the sheet is sealed towards the casing at the  
bottom and the top of the package (12) and at the ends of  
the package as to prevent leakages between the media.

2. A heat exchanger as claimed in claim 1, c h a r -  
a c t e r i z e d in that the pattern of the sheet is in  
20 the form of corrugations extending at an oblique angle to  
the lengthwise extension of the sheet.

3. A heat exchanger as claimed in claim 2, c h a r -  
a c t e r i z e d in that the corrugation in the sheet is  
interrupted at suitable intervals and replaced by folding  
25 lines (9) to facilitate folding of the sheet.

4. A heat exchanger as claimed in claim 2 or 3,  
c h a r a c t e r i z e d in that the angle of the  
corrugations to the lengthwise extension of the sheet is  
less than 45°.

30 5. A heat exchanger as claimed in any of the above  
claims, c h a r a c t e r i z e d in that the pattern of  
the sheet is such that the resistance to flow towards the  
ends of the sheet packet becomes higher in the intended  
direction of flow than crosswise to said direction, while  
35 the resistance to flow in the mid-section of the sheet  
package is low in the intended direction of flow.

6. A heat exchanger as claimed in any of the above claims, characterized in that the seals at the two ends of the package coincide with two opposite side walls of the casing.

5 7. A method of producing a recuperative heat exchanger for the transfer of heat between two media across a separating heat transferring wall, characterized by

10 a) folding a shaped patterned sheet (1) of a heat transferring material repeatedly to form a multi-layered package and enclosing said package in a casing (20, 21; 28, 34, 35);

15 b) sealing the lengthwise edges of the sheet, i.e. the edges at right angles to the folds, with lid-forming elements (12); and

20 c) enclosing the package (12) thus formed by the folded sheet in a casing and sealing said package at its top and bottom with respect to that casing so that the two opposite side faces of the sheet are facing two spaces that are separate from each other in the casing and are equipped each one with an inlet and an outlet part for each one of said media.

25 8. A method as claimed in claim 7, characterized by producing the shaped pattern in the sheet (1) by stamping the sheet by advancing it continuously between at least two shaping rollers (2, 3) having appropriate protuberances and depressions (5, 6) corresponding to the configuration of the desired pattern to be imparted to the sheet and possibly incorporating 30 axial ridges (7) and grooves (8) to make folding lines in said sheet.

9. A method as claimed in claim 7 or 8, characterized in that said lid-forming sealing elements are made by moulding of a solidifying compound.

## PATENT COOPERATION TREATY

RECEIVED

1996-08-21

AWAPATENT, Göteborg

From the  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

To:

Awapatent AB  
Box 11394  
404 28 GÖTEBORG

BL	

NOTIFICATION OF TRANSMITTAL OF  
INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing  
(day/month/year)

20-08-1996

Applicant's or agent's file reference

2956122

## IMPORTANT NOTIFICATION

International application No.

PCT/SE95/00479

International filing date (day/month/year)

02-05-1995

Priority date (day/month/year)

06-05-1994

Applicant

Heed, Björn

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.
4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/  
Patent- och registreringsverket  
Box 5055  
S-102 42 STOCKHOLM  
Facsimile No. 08-667 72 88

Telex  
17978  
PATOREG-S

Authorized officer

Telephone No. 08-782 25 00



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>F28D 9/00, B21D 53/04</b>	<b>A1</b>	(11) International Publication Number: <b>WO 95/30867</b>
		(43) International Publication Date: 16 November 1995 (16.11.95)

(21) International Application Number: PCT/SE95/00479

(22) International Filing Date: 2 May 1995 (02.05.95)

(30) Priority Data:  
9401567-4 6 May 1994 (06.05.94) SE

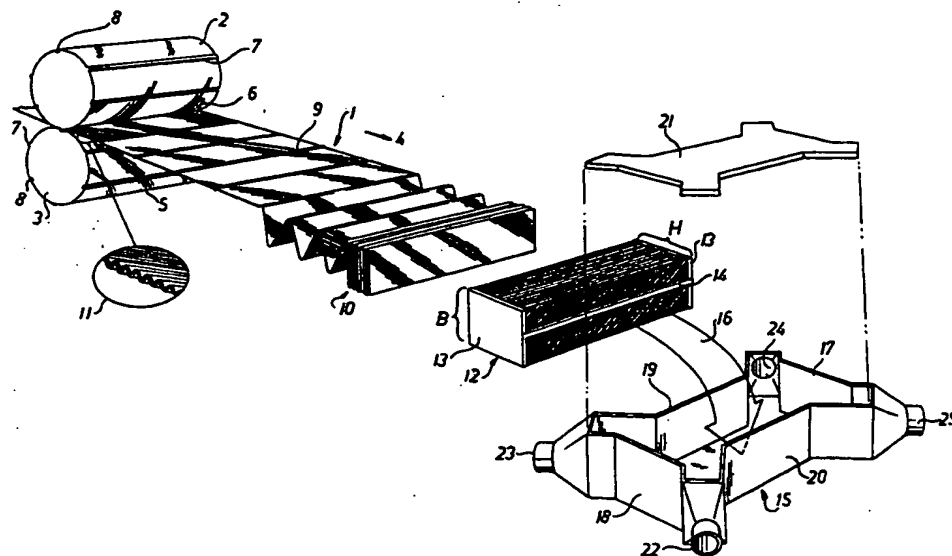
(71)(72) Applicant and Inventor: HEED, Björn [SE/SE]; Utlandagatan 19, S-412 61 Göteborg (SE).

(74) Agent: AWAPATENT AB; P.O. Box 11394, S-404 28 Göteborg (SE).

(81) Designated States: AM, AT, AT (Utility model), AU, BB, BG, BR, BY, CA, CH, CN, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, ES, FI, FI (Utility model), GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), TJ, TM, TT, UA, UG, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).

**Published***With international search report.**In English translation (filed in Swedish).*

(54) Title: HEAT EXCHANGER AND METHOD FOR ITS MANUFACTURE



## (57) Abstract

The invention regards a recuperative heat exchanger for the exchange of heat between two media across a heat transferring wall. According to the invention the heat transferring wall is made from a shaped patterned sheet which is folded repeatedly to form a multi-layered package (12) which is enclosed in a casing (15, 21), so that the sheet, owing to its configuration, after folding forms a package of alternating flow channels with connecting ports (22-25) for the two media at two opposite sides of the sheet package, said sheet being sealed against the casing at the bottom and the top of the package and at the two ends of the package so that leakage between the two media is prevented. The invention also relates to a method of producing such a heat exchanger.



## Heat exchanger and method for its manufacture.

The present invention concerns a recuperative heat  
5 exchanger for the transfer of heat between two media  
through a heat transferring wall, and a method of produc-  
ing such a heat exchanger.

Heat exchangers are used for the transfer of heat  
between two media flows of different temperatures. In the  
10 conventional heat exchanger of so called recuperative type  
heat is transferred from the hot medium through a separat-  
ing wall to the cooler medium. The design often comprises  
tubes inside which one of the media flows whereas the  
outer medium flows outside the tubes. This type of heat  
15 exchanger is often called tube-and-shell heat exchangers.  
It is also common practice to separate the media by means  
of more or less flat separating plates. This type of heat  
exchangers is often called plate heat exchangers.

If the heat exchanger is to serve its function of  
20 transferring heat it is important that the heat transfer  
surface area is as large as possible. This is often  
accomplished by dividing the media flows into multiple  
parallel part flows moving inside alternately juxtaposed  
passageways to form a unit with a large transfer surface  
25 area within a limited volume. The devices that are  
necessary for the separation of the flows into parallel  
streams are often complicated and expensive to produce.  
Often, the specifications for inter-flow leak sealing are  
stringent.

30 Except when subject to boiling or condensation the  
media change their temperature when passing through the  
heat exchanger. The temperature of the hot medium  
gradually decreases and the temperature of the cooler  
medium gradually increases. When the temperature  
35 difference between the media is small it is important that  
the flow geometry in the heat exchanger is such that the  
hottest part (the beginning) of the hot flow heats the

hottest part (the end) of the cool flow and that the coldest part (the end) of the hot flow heats the coldest part (the beginning) of the cool flow. Using such counter-current flow geometry in the heat exchanger makes it possible to achieve such a degree of heat exchange that the outgoing temperature of the cool flow is higher than the outgoing temperature of the hot flow. This is not possible when using a flow geometry where the media travel in the same direction through the heat exchanger, i.e. so called parallel flow heat exchangers.

To achieve optimum heat transfer in the heat exchanger it is necessary that the heat transfer between each medium and the separating wall is as good as possible. This can be accomplished by designing the separating wall in such a manner that it promotes the generation of a turbulent, well mixed, vortex filled flow in the medium that is in contact with the wall. Thus, when designing a heat exchanger there are three important objectives to consider, of which at least one and preferably all three should be accomplished. These objectives are:

1) Arrangement of each flow to be distributed over several parallel passageways in such a way that the passageways are alternately in juxtaposed relationship so as to have a large total heat transfer surface area.

2) Heat transfer walls in the heat exchanger that contribute to the generation of a turbulent flow with good heat transfer to the wall.

3) Counter-current flow of the media in the heat exchanger.

These objectives can be difficult to achieve. Especially objectives number 1 and 3 have proved difficult to achieve at the same time without causing high costs.

The present invention relates to a heat exchanger wherein all three objectives are met simultaneously while the costs are kept low.

The invention will be described in the following in closer detail by way of an example with reference to the accompanying drawings, wherein:

FIGURE 1 in a perspective view shows important steps  
5 of the manufacture of a heat exchanger according to the present invention.

FIGURE 2 is a perspective view of a heat exchanger according to the invention depicted in a not fully closed state in order to show the internal flows of the media.

10 FIGURE 3 is a perspective view of a part of the heat transferring walls in the same heat exchanger.

FIGURE 4 is a perspective view of a heat exchanger according to the invention in accordance with a slightly different embodiment and shown in a not fully closed  
15 state.

A heat exchanger according to the invention preferably is produced as shown in Figure 1 from a continuous sheet 1 of metal, plastic or other suitable material which in the completed heat exchanger will serve as a heat  
20 transferring wall. In Figure 1 numeral references 2 and 3 denote rollers between which the sheet is fed in the direction of arrow 4. The surfaces of the rollers are formed with patterns of oblique ridges and grooves 5 and 6. Furthermore, the rollers are formed with ridges 7 and  
25 grooves 8 extending in parallel with the roller axis. Every ridge 7 corresponds to a groove 8 on the opposite roller. Accordingly, when the sheet passes between the rollers, the ridges 7 and the grooves 8 form folding lines 9 in the sheet. Since in sequence along the circumference  
30 of each roller a ridge 7 is followed by a groove 8 the folding lines will be pressed alternately in one and the other of the opposite sides of the sheet. This makes it easy to fold the sheet at the folding lines into a package  
10 comprised by a number of juxtaposed layers. The oblique pattern 5 and 6 on the rollers gives the band a corrugated  
35 configuration best visible in the encircled enlargement 11 in Figure 1. The sheet is cut to suitable lengths so that

an appropriate thickness of the package 10 is obtained. In Figure 1 a complete finished package is represented by numeral 12. The ends of the package 12 are closed by covering elements 13 which may be produced for instance by dipping the package ends into a compound that is soft from the beginning but after a while solidifies when cooling or by chemical reaction. Numeral reference 14 relates to a sealing strip which is applied to one side of the package, e.g. the bottom part. A corresponding seal, not visible in the drawing, is applied to the opposite side of the package. Numeral reference 15 denotes a box-shaped casing 15 generally, into which the package 12 is intended to be placed as indicated by arrow 16. When the package is thus placed inside the casing, the seal 14 will be forced against the bottom of the casing and the covering elements 13 will seal against the end walls 17 and 18 of the casing. Preferably, the width B of the package 12 essentially corresponds to the spacing between the side walls 19 and 20 of the casing while the height H of the package essentially corresponds to the height of the casing. The casing 15 has a lid 21 the shape of which matches that of the open upper side of the casing 15 in Figure 1. At the corners of the casing 15 connecting ports 22 - 25 are arranged. The connecting ports 22 and 25 serve as inlet and outlet ports respectively for one of the media and connecting ports 23 and 24 serve as inlet and outlet ports respectively for the other medium. When the lid 21 is fitted while the package 12 is in the casing 15 the lid will seal against the top face of the package 12. The sealing strips 14 and the covering elements 13 prevent the two media from mixing and thus the media are kept separate, one on either side of package 12 and thus on either side of the folded sheet. Figure 2, for the sake of clarity showing the upper part of the package slightly raised, illustrates the flow paths of the two media. The directions of flow are shown by arrows 26 for one of the media and with arrows 27 for the other medium. As is most

clearly apparent from Figure 3 the corrugations in one layer of the folded sheet will extend crosswise with respect to the corrugations in the next layer. These crossing corrugations formed in the facing sides of adjacent layers create a turbulent flow in the medium flowing between the layers. To a considerable extent, this will contribute to an efficient exchange of heat between the two media.

In the example shown the sheet is given a corrugated pattern but within the scope of this invention shaped patterns of different configuration that create turbulence in the inter-layer space may also be used. In the example shown the shaped pattern was made by means of rollers, but the shaped pattern can also be accomplished by stamping.

As mentioned above, the covering elements 13 are made of a solidifying compound. However, it is within the scope of the invention to produce the covering elements 13 as separate lids which with an intermediate soft layer that is pressed against the ends of the package. It is also possible to use layers of soft material between the ends of the package and the end walls of the outer casing. The casing 15 and the lid 21 thus form an outer shell that together with the seals 13 and 14 on the package 12 constitutes an efficient media flow separating and sealing means. The seal shown in the figures could however, be made in a very simple and inexpensive manner. The application of the sealing compound or other soft material can be made without high precision or geometrical exactness. A sealing effect could also be accomplished by a good fit only or by soldering or welding when suitable materials, therefor are used.

In contrast to the example described above, wherein a casing 15 with a lid 21 forms a shell around the package 12, this shell is formed according to Figure 4 by a box 28 having a rectangular cross sectional shape. On one side, the box is equipped with an inlet port 29 and an outlet port 30 for one of the media and on the other side with an

inlet port 31 and an outlet port 32 for the other medium. In this example the package 12 is inserted through one open end of the box which thus forms a casing 33 which may be closed by lids 34 and 35. The lids 34 and 35 are  
5 designed to seal against the ends of the package 12, either by themselves or by means of intermediate sealing layers. The lower lid 34 in Figure 4 could for instance be fastened by means of a liquid sealing compound which is poured into the lid and which solidifies after the  
10 assembly 28, 12 has been dipped into it. The other lid 35 can then be fastened in the same way after the assembly 28, 12 having been turned upside down. This kind of moulding can also be used in the example shown in Figures 1 and 2. When using an appropriate sealing compound the  
15 lids may be removed after the moulding operation and thus only serve as moulds in the moulding process.

The shaped pattern in the sheet serves at least three purposes. One is to establish a certain distance or pitch between successive layers in the folded sheet so that a  
20 medium can flow in the inter-layer space. The shaped pattern should also promote turbulence in the flow as described earlier.

The simple pattern described above serves both these purposes. As mentioned above, after folding of the sheet  
25 the oblique corrugations form a system of crossing ridges. The ridges maintain a certain spacing between the different folds and produce a tortuous, turbulence-inducing flow path for the medium which, as mentioned above, promotes heat transfer to the wall.

30 Owing to the design of the heat exchanger, the two media flows are distributed over a number of parallel channels that are placed in alternating nesting position. The third purpose of the shaped pattern is to achieve an evenly distribution of the flow sideways within and across  
35 each channel. Thus an essentially counter-current flow pattern is established between the two media flows even when their inlet and outlet ports do not extend in the

prolongation of the flow direction.

An efficient lateral spread of the flow of this kind is achieved if the resistance to flow sideways is lower than the resistance of flow lengthwise in the channel.

5 This result is obtained with the proposed simple corrugation of the sheet if the angle of the corrugations to the longitudinal extension of the sheet is less than  $45^\circ$ , or differently expressed, if the angle of the corrugations to the intended direction of flow is more  
10 than  $45^\circ$ .

The simple corrugation pattern which has been used as an example above is easy to produce between two helically cut rollers as in Figure 1. It is also well suited to fulfill the objects of keeping the spacing between the  
15 layers, and of promoting turbulence and lateral distribution of the flow as have been discussed above. Many other stamped patterns are also possible, as mentioned above. To facilitate the folding of the sheet the corrugations preferably could be interrupted and be  
20 replaced by folding lines at suitable spaced-apart intervals as shown in Figure 1. Another improvement of the pattern would be to provide the inlet and outlet areas (the outer parts of the sheet) with a different pattern from the main part of the sheet area so as to give an  
25 efficient lateral distribution of the flow without making the lengthwise resistance to flow too high in the main part of the heat exchanger. A reduction of the resistance to flow in the heat transferring part of the heat exchanger most often however involves a reduction of the  
30 heat transfer there, which is not desirable.

The invention is not limited to the above described examples but can be varied as to its details within the framework of the following claims without departing from the scope of protection of the invention.

## CLAIMS

1. A recuperative heat exchanger for the exchange of  
5 heat between two media across a heat-transferring wall,  
c h a r a c t e r i z e d in that:

- a) the media separating a heat transferring wall is made from a shaped patterned sheet which is repeatedly folded to form a multi-layered package which is enclosed  
10 in an outer casing (15, 21; 28, 34, 35);
- b) owing to its shaping after folding the sheet forms a package (10, 12) of alternating flow channels having connecting ports (22-25; 29-32) for the two media on the two opposite sides of the package; and
- 15 c) the sheet is sealed towards the casing at the bottom and the top of the package (12) and at the ends of the package as to prevent leakages between the media.

2. A heat exchanger as claimed in claim 1, c h a r -  
a c t e r i z e d in that the pattern of the sheet is in  
20 the form of corrugations extending at an oblique angle to the lengthwise extension of the sheet.

3. A heat exchanger as claimed in claim 2, c h a r -  
a c t e r i z e d in that the corrugation in the sheet is interrupted at suitable intervals and replaced by folding  
25 lines (9) to facilitate folding of the sheet.

4. A heat exchanger as claimed in claim 2 or 3,  
c h a r a c t e r i z e d in that the angle of the corrugations to the lengthwise extension of the sheet is less than  $45^\circ$ .

30 5. A heat exchanger as claimed in any of the above claims, c h a r a c t e r i z e d in that the pattern of the sheet is such that the resistance to flow towards the ends of the sheet packet becomes higher in the intended direction of flow than crosswise to said direction, while  
35 the resistance to flow in the mid-section of the sheet package is low in the intended direction of flow.



6. A heat exchanger as claimed in any of the above claims, c h a r a c t e r i z e d in that the seals at the two ends of the package coincide with two opposite side walls of the casing.

5        7. A method of producing a recuperative heat exchanger for the transfer of heat between two media across a separating heat transferring wall, c h a r - a c t e r i z e d by

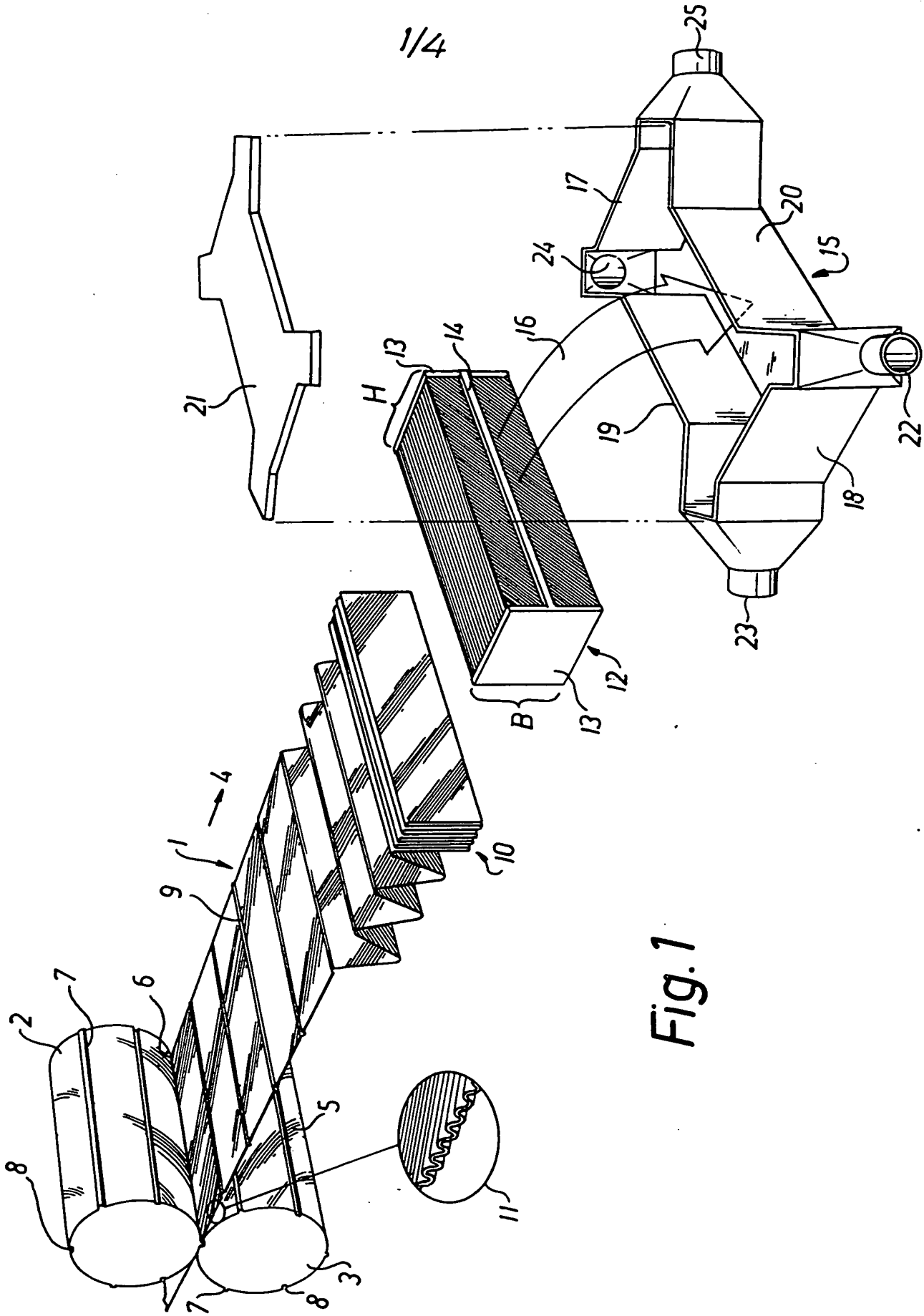
10        a) folding a shaped patterned sheet (1) of a heat transferring material repeatedly to form a multi-layered package and enclosing said package in a casing (20, 21; 28, 34, 35);

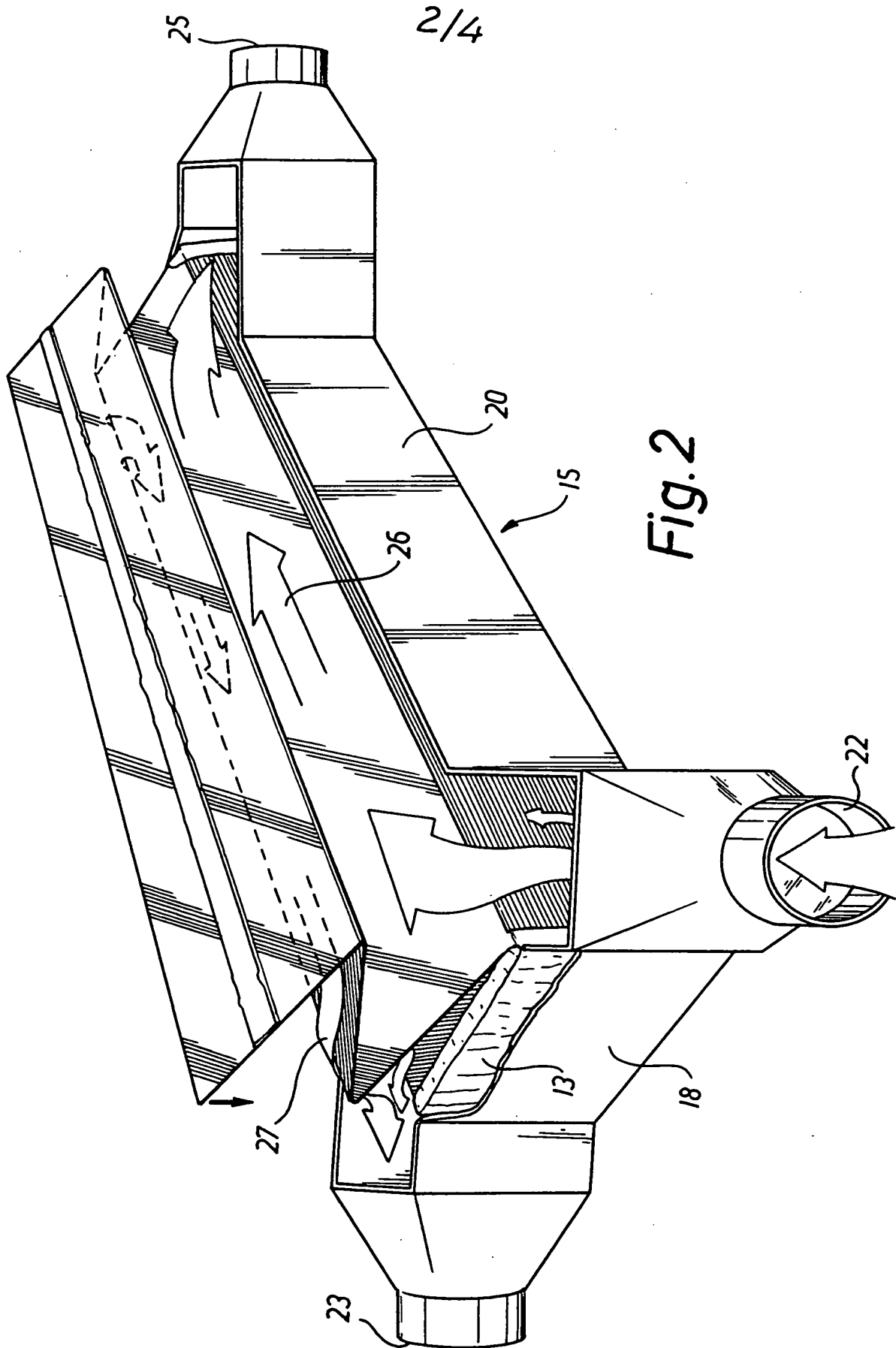
15        b) sealing the lengthwise edges of the sheet, i.e. the edges at right angels to the folds, with lid-forming elements (12); and

20        c) enclosing the package (12) thus formed by the folded sheet in a casing and sealing said package at its top and bottom with respect to that casing so that the two opposite side faces of the sheet are facing two spaces that are separate from each other in the casing and are equipped each one with an inlet and an outlet part for each one of said media.

25        8. A method as claimed in claim 7, c h a r a c - t e r i z e d by producing the shaped pattern in the sheet (1) by stamping the sheet by advancing it continuously between at least two shaping rollers (2, 3) having appropriate protuberances and depressions (5, 6) corresponding to the configuration of the desired pattern to be imparted to the sheet and possibly incorporating 30 axial ridges (7) and grooves (8) to make folding lines in said sheet.

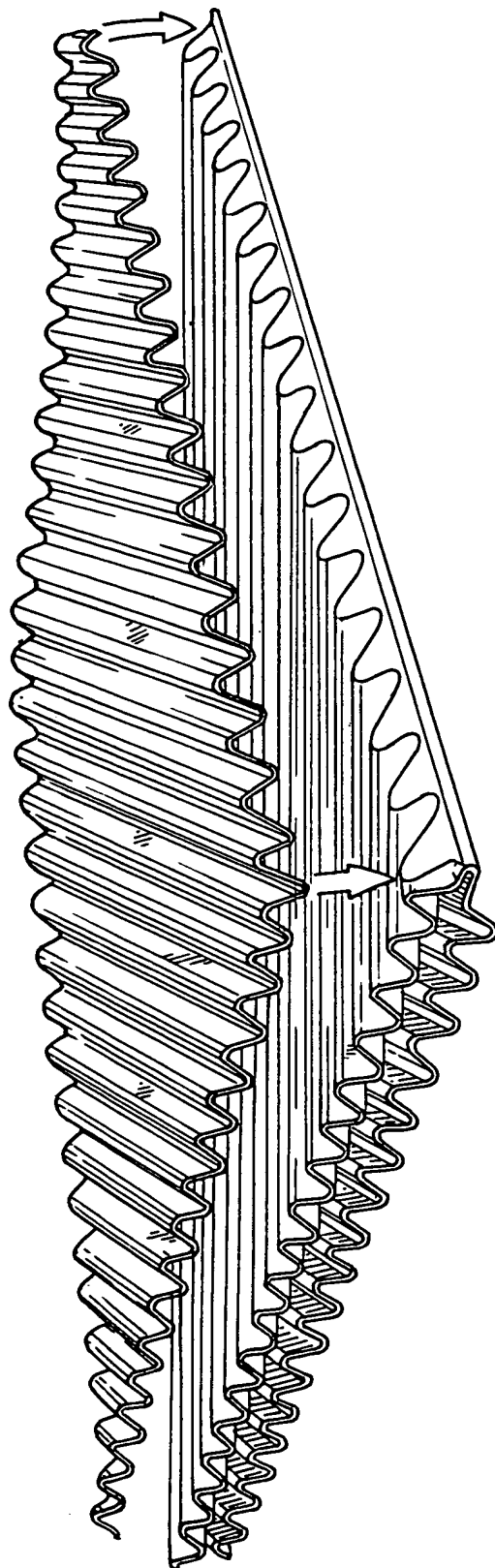
9. A method as claimed in claim 7 or 8, c h a r - a c t e r i z e d in that said lid-forming sealing elements are made by moulding of a solidifying compound.





3/4

Fig. 3



4/4

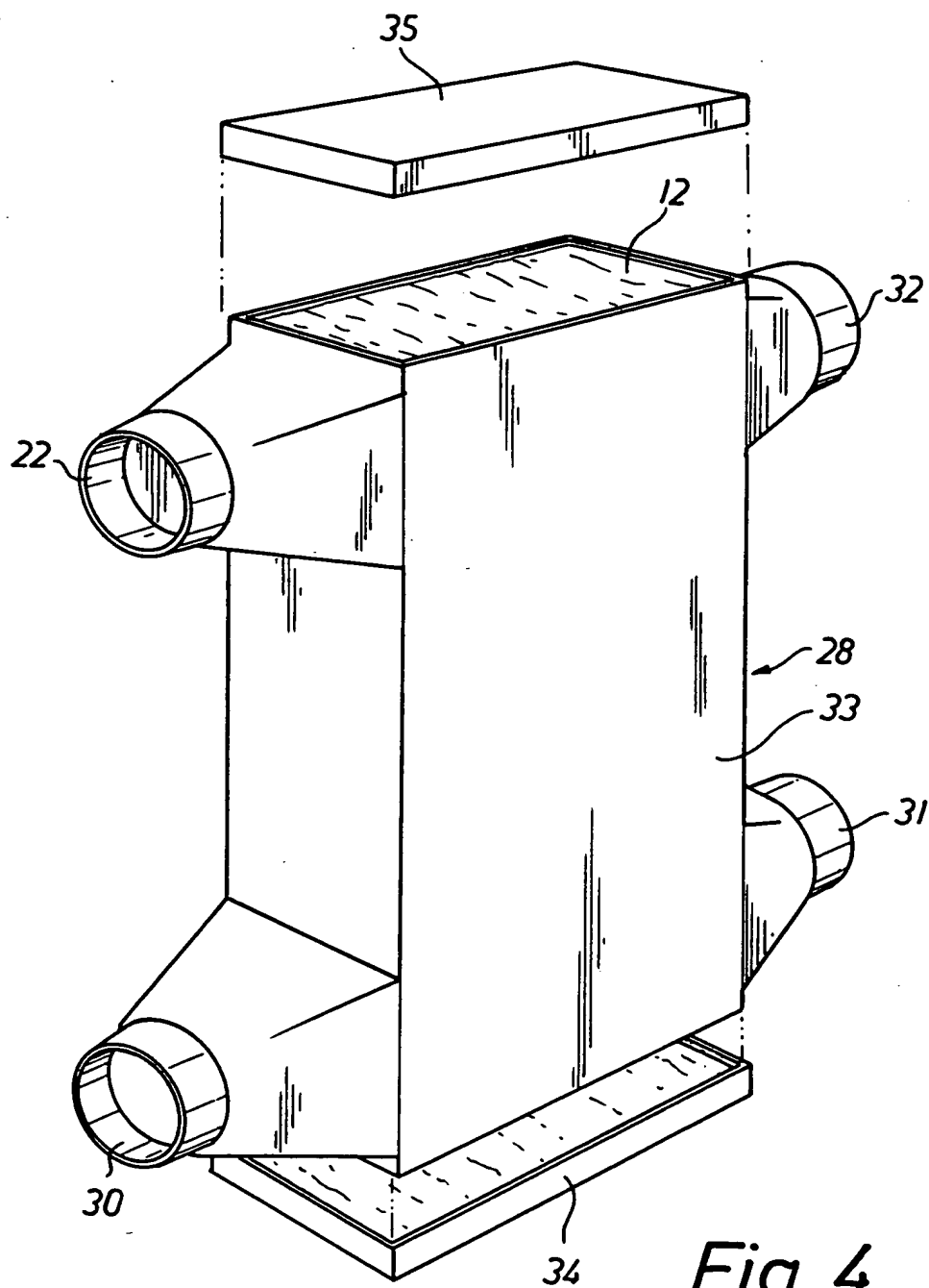


Fig. 4

1  
INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 95/00479

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC6: F28D 9/00, B21D 53/04

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC6: F28D, B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2190481 A (IAN DONALD MCKIRDY), 18 November 1987 (18.11.87) --	1,6,7
X	US 5224538 A (JACOBY), 7 June 1993 (07.06.93) --	1
X	DE 2408462 A1 (KERNFORSCHUNGSANLAGE JÜLICH GMBH), 28 August 1975 (28.08.75) --	1
X	Patent Abstracts of Japan, Vol 6, No 124, M-141, abstract of JP, A, 57-49793 (TOKYO SHIBAURA DENKI K.K.), 23 March 1982 (23.03.82) --	1

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

14 July 1995

Date of mailing of the international search report

18 -07- 1995

Name and mailing address of the ISA/  
Swedish Patent Office  
Box 5055, S-102 42 STOCKHOLM  
Facsimile No. +46 8 666 02 86

Authorized officer

Annette Riedel  
Telephone No. +46 8 782 25 00

2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 95/00479

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 1569887 A (M.A.N. TURBO G.M.B.H.), 6 June 1969 (06.06.69)	1-7
Y	--	8,9
X	US 4043388 A (ZEBUHR), 23 August 1977 (23.08.77)	1,6,9
Y	--	8
Y	SE 352724 B (THERMOVATIC SVERRE K. JENSSEN AB), 8 January 1973 (08.01.73)	2-4
Y	SE 374193 B (BAXTER LABORATORIES, INC.), 24 February 1975 (24.02.75)	6,9
Y	DE 3416840 A1 (ETABLISSEMENT AGURA), 7 November 1985 (07.11.85)	8
	-----	

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

29/05/95

International application No.

PCT/SE 95/00479

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
GB-A-	2190481	18/11/87	NONE		
US-A-	5224538	07/06/93	NONE		
DE-A1-	2408462	28/08/75	NONE		
FR-A-	1569887	06/06/69	GB-A-	1201715	12/08/70
			US-A-	3508607	28/04/70
US-A-	4043388	23/08/77	NONE		
SE-B-	352724	08/01/73	DE-A-	2053718	10/05/72
			FR-A,B-	2067079	13/08/71
			GB-A-	1267143	15/03/72
			US-A-	3719227	06/03/73
SE-B-	374193	24/02/75	AU-B-	459807	10/04/75
			AU-A-	3441471	19/04/73
			BE-A,A-	773651	31/01/72
			CA-A-	942291	19/02/74
			CH-A-	538658	15/08/73
			DE-A-	2156295	31/05/72
			FR-A,B-	2115261	07/07/72
			GB-A-	1327578	22/08/73
			US-A-	3640340	08/02/72
DE-A1-	3416840	07/11/85	NONE		



**RECORD COPY**

**PCT**

**REQUEST**

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

▲ The title changed see ISR

For receiving Office use only

International Application No. PCT/SE 95/00479

International Filing Date (02 -05- 1995)  
02 MAY 1995

The Swedish Patent Office  
PCT International Application  
Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference  
(if desired) (12 characters maximum) 2956122

**Box No. I TITLE OF INVENTION**

[HEAT EXCHANGER] ▲

**Box No. II APPLICANT**

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

HEED, Björn  
Utländagatan 19  
S-412 61 GÖTEBORG  
Sweden

☒ This person is also inventor.

Telephone No.  
+46 31 201748

Facsimile No.  
+46 31 181746

Teleprinter No.

State (i.e. country) of nationality:  
Sweden

State (i.e. country) of residence:  
Sweden

This person is applicant for the purposes of: ☒ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

**Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)**

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

This person is:

- ☐ applicant only  
☐ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (i.e. country) of nationality:

State (i.e. country) of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on a continuation sheet.

**Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE**

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

AWAPATENT AB  
Box 11394  
S-404 28 GÖTEBORG  
Sweden

Telephone No.  
+46 31 80 73 50

Facsimile No.  
+46 31 15 00 60

Teleprinter No.  
32407 awapat S

☐ Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

## Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) (mark the applicable check-boxes; at least one must be marked):

## Regional Patent

- ☒ AP ARIPO Patent: KE Kenya, MW Malawi, SD Sudan, SZ Swaziland and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ EP European Patent: AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, DE Germany, DK Denmark, ES Spain, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ OA OAPI Patent: BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line) .....

National Patent (if other kind of protection or treatment desired, specify on dotted line):

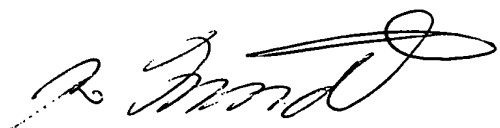
- ☒ AM Armenia ..... ☒ MD Republic of Moldova .....
- ☒ AT Austria + Utility Model ..... ☒ MG Madagascar .....
- ☒ AU Australia ..... ☒ MN Mongolia .....
- ☒ BB Barbados ..... ☒ MW Malawi .....
- ☒ BG Bulgaria ..... ☒ MX Mexico .....
- ☒ BR Brazil ..... ☒ ~~NL Netherlands~~ ] .....
- ☒ BY Belarus ..... ☒ NO Norway .....
- ☒ CA Canada ..... ☒ NZ New Zealand .....
- ☒ CH and LI Switzerland and Liechtenstein ..... ☒ PL Poland .....
- ☒ CN China ..... ☒ PT Portugal .....
- ☒ CZ Czech Republic + Utility Model ..... ☒ RO Romania .....
- ☒ DE Germany + Utility Model ..... ☒ RU Russian Federation .....
- ☒ DK Denmark + Utility Model ..... ☒ SD Sudan .....
- ☒ EE Estonia ..... ☒ SE Sweden .....
- ☒ ES Spain ..... ☒ SI Slovenia .....
- ☒ FI Finland + Utility Model ..... ☒ SK Slovakia + Utility Model .....
- ☒ GB United Kingdom ..... ☒ TJ Tajikistan .....
- ☒ GE Georgia ..... ☒ TT Trinidad and Tobago .....
- ☒ HU Hungary ..... ☒ UA Ukraine .....
- ☒ JP Japan ..... ☒ US United States of America .....
- ☒ KE Kenya ..... ☒ UZ Uzbekistan .....
- ☒ KG Kyrgyzstan ..... ☒ VN Viet Nam .....
- ☒ KP Democratic People's Republic of Korea ..... ☐ .....
- ☒ KR Republic of Korea ..... ☐ .....
- ☒ KZ Kazakhstan ..... ☐ .....
- ☒ LK Sri Lanka ..... ☒ UG Uganda .....
- ☒ LR Liberia ..... ☒ SG Singapore .....
- ☒ LT Lithuania ..... ☒ IS Island .....
- ☒ LU Luxembourg ..... ☒ TM Turkmenistan .....
- ☒ LV Latvia ..... ☐ .....

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

- ☒ UG Uganda .....
- ☒ SG Singapore .....
- ☒ IS Island .....
- ☒ TM Turkmenistan .....
- ☐ .....

In addition to the designations made above, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except the designation(s) of .....  
The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)

deleted  
RO/SE

<b>Box No. VI PRIORITY CLAIM</b>		Further priority claims are indicated in the Supplemental Box <input type="checkbox"/>	
The priority of the following earlier application(s) is hereby claimed:			
Country (in which, or for which, the application was filed)	Filing Date (day/month/year)	Application No.	Office of filing (only for regional or international application)
item (1) Sweden	(06.05.1994) 6 May 1994	9401567-4	
item (2)			
item (3)			
Mark the following check-box if the certified copy of the earlier application is to be issued by the Office which for the purposes of the present international application is the receiving Office (a fee may be required):			
<input checked="" type="checkbox"/> The receiving Office is hereby requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s) : (1)			
<b>Box No. VII INTERNATIONAL SEARCHING AUTHORITY</b>			
Choice of International Searching Authority (ISA) (If two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used): ISA / SE			
Earlier search Fill in where a search (international, international-type or other) by the International Searching Authority has already been carried out or requested and the Authority is now requested to base the international search, to the extent possible, on the results of that earlier search. Identify such search or request either by reference to the relevant application (or the translation thereof) or by reference to the search request: Country (or regional Office):      Date (day/month/year):      Number:			
<b>Box No. VIII CHECK LIST</b>			
This international application contains the following number of sheets: 1. request : <input checked="" type="checkbox"/> 3 sheets 2. description : <input checked="" type="checkbox"/> 7 sheets 3. claims : <input checked="" type="checkbox"/> 2 sheets 4. abstract : <input checked="" type="checkbox"/> 1 sheets 5. drawings : <input checked="" type="checkbox"/> 4 sheets  Total : <input checked="" type="checkbox"/> 17 sheets		This international application is accompanied by the item(s) marked below: 1. <input type="checkbox"/> separate signed power of attorney 2. <input type="checkbox"/> copy of general power of attorney 3. <input type="checkbox"/> statement explaining lack of signature 4. <input checked="" type="checkbox"/> priority document(s) identified in Box No. VI as item(s): 5. <input checked="" type="checkbox"/> fee calculation sheet 6. <input type="checkbox"/> separate indications concerning deposited microorganisms 7. <input type="checkbox"/> nucleotide and/or amino acid sequence listing (diskette) 8. <input checked="" type="checkbox"/> other (specify): Copy of Official Letter	
Figure No. <u>1</u> of the drawings (if any) should accompany the abstract when it is published.			
<b>Box No. IX SIGNATURE OF APPLICANT OR AGENT</b>			
Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).			
Göteborg 28 April 1995			
			
Bo Lindberg			

For receiving Office use only	
1. Date of actual receipt of the purported international application: 02-05-1995	2. Drawings: <input checked="" type="checkbox"/> received: <input type="checkbox"/> not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority specified by the applicant: ISA / SE	
6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid	

For International Bureau use only	
Date of receipt of the record copy by the International Bureau: 07 JUNE 1995	(07.05.95)

Kontor/handläggare  
Göteborg/Bo Lindberg/IAG

Pans  
9401567-4

Ref  
2946111

### VÄRMEVÄXLARE

5           Föreliggande uppfinning avser en rekuperativ värmeväxlare för värmeväxling mellan två medier via en värmeöverförande vägg jämte ett sätt att framställa en dylik värmeväxlare.

10           Värmeväxlare användes för att överföra värme mellan två strömmande medier av olika temperatur. I den vanliga s k rekuperativa typen av värmeväxlare sker detta genom att värme överföres från det varmare mediet genom en åtskiljande vägg till det kallare mediet. Konstruktionsmässigt rör det sig ofta om rörväggar där det ena mediet 15 strömmar inuti röret och det andra flödet strömmar utanför detsamma. En vanlig benämning för sådana värmeväxlare är tubvärmeväxlare. Det är också vanligt att medierna skiljs åt av mer eller mindre plana skiljeplåtar. Man talar då ofta om plattvärmeväxlare.

20           För värmeväxlarens funktion att överföra värme är det väsentligt att den värmeöverförande ytan är så stor som möjligt. Detta åstadkommes ofta genom att de båda medieströmmarna uppdelas i många parallella delströmmar i ömsevis intill varandra placerade kanaler som bildar en enhet 25 med stor värmeöverförande yta inom en begränsad volym. De system som krävs för fördelning av flödena i flera parallella strömmar blir dock ofta komplicerade och dyrbara i tillverkning. Många gånger är kraven på läckagetäthet mellan flödena stor.

30           Utom när det sker kokning eller kondensation ändras mediernas temperatur vid passagen igenom värmeväxlaren. Det varma mediets temperatur sjunker successivt och det kalla mediets temperatur ökar successivt. När temperaturskillnaden mellan flödena är liten är det viktigt att 35 strömningsgeometrin i växlaren är sådan, att den varmare delen (början) av det varma flödet värmer den varmaste delen (slutet) av det kalla flödet och att den kallaste

delen av det varma flödet (slutet) värmer den kallaste delen (början) av det kalla flödet. Med en sådan s k motströmskoppling i värmeväxlaren blir det möjligt att åstadkomma sådan värmeväxling att utgående temperatur på det kalla flödet ligger högre än utgående temperatur hos det varma flödet. Med en koppling av flödena så, att de i stället sammanfaller i riktning genom värmeväxlaren, s k medströmskoppling, är detta icke möjligt.

För att värmeöverföringen i värmeväxlaren skall bli så bra som möjligt fordras också att värmeöverföringen mellan respektive medium och den skiljande väggen är så bra som möjligt. För att ge en god värmeöverföring till väggen kan den med fördel utformas så att den bidrager till ett turbulent, omblandat och virvelfyllt flöde hos de medium som strömmar i kontakt med väggen. Det finns alltså tre viktiga önskemål beträffande konstruktionen hos en värmeväxlare, av vilka åtminstone något, helst alla tre, bör vara uppfyllda. Dessa önskemål är:

1) Flera parallella strömningskanaler för vardera flödet som är så arrangerade, att kanalerna ligger ömsvis och gränsar mot varandra med sammanlagt stor värmeöverförande yta.

2) Värmeöverförande väggar i värmeväxlaren som bidrager till omblandat flöde med god värmeöverföring till väggen.

3) Motströms flöde av medierna i värmeväxlaren.

Dessa önskemål kan vara svåra att tillmötesgå. Det har särskilt varit svårt att uppfylla önskemålen 1 och 3 samtidigt utan att kostnaderna blir höga.

Föreliggande uppfinning ger en värmeväxlare där alla tre kraven kan uppfyllas samtidigt och kostnaderna blir låga.

I det följande beskrives uppfinningen närmare i form av utföringsexempel med hänvisning till bifogade ritningar, på vilka:

## 3

FIG 1 schematiskt i perspektiv visar viktiga delar i tillverkningen av en värmeväxlare enligt uppfinningen;

FIG 2 är en perspektivvy av en värmeväxlare enligt uppfinningen visad i ej helt tillslutet skick för åskåd-  
5 liggörande av mediernas strömning däri;

FIG 3 visar i perspektiv en del av de värmeöverförande väggarna i samma värmeväxlare; och

FIG 4 är en perspektivvy av en värmeväxlare enligt uppfinningen med ett något annorlunda utförande visad i ej  
10 helt tillslutet skick.

Lämpligen tillverkas värmeväxlaren enligt uppfinningen såsom visas i fig 1 av ett kontinuerligt band 1 av metall, plast eller annat lämpligt material, som i den färdiga värmeväxlaren bildar en värmeöverförande vägg. I  
15 fig 1 betecknas med 2 respektive 3 två valsar mellan vilka bandet matas i riktningen av pilen 4. De visade valsarna är försedda med snedlöpande upphöjningar och fördjupningar 5, 6. Vidare är valsarna försedda med axelparallellt löpande listformiga utsprång 7 och fördjupningar 8, lika-  
20 ledes med axelparallell sträckning. Varje listformigt utsprång 7 på den ena valsen motsvarar en fördjupning 8 hos den motstående valsen. Vid bandets passage mellan valsarna bildar upphöjningarna 7 och fördjupningarna 8 bigningslinjer 9 på bandet. Då i omkretsriktningen räknat en upp-  
25 höjning 7 följs av en fördjupning 8 på valsarna kommer bigningarna 9 att vara växelvis pressade mot ena respektiva andra sidan av bandet så, att detsamma lätt kan omvikas vid bigningslinjerna till bildande av paket 10 med ett antal inbördes sammanlagda skikt. Genom den snedlöpande mönstringen 5, 6 på valsarna bildas en vågformad  
30 prägling av bandet som tydligast framgår av förstoringen 11 i fig 1. Bandet kapas i lämpliga längder för erhållande av lämplig tjocklek på paketet 10. I fig 1 markeras med 12 i dess helhet ett helt färdigställt paket. I paketet 12 är dess ändar tillslutna med lockbildande element 13 som  
35 exempelvis kan åstadkommas genom paketets neddoppning i från början mjuk och efter en stund exempelvis genom sval-

ning eller härdning stelnde massa. Med 14 betecknas en tättningssträng som är anordnad på den ena, exempelvis bottendelen av packen. En motsvarande tätning, ej synlig på ritningen, är anordnad på den motsatta sidan av packen.

5 Med 15 betecknas i dess helhet ett lådformigt ytterhölje, i vilket packen 12 är avsedd att nedläggas enligt den med 16 markerade pilen. När packen nedlägges så i lådan kommer tättningslisten 14 att pressas mot lådans botten och de lockbildande elementen 13 att täta på lådans gavlar 17 och

10 18. Lämpligen motsvarar packens 12 bredd B i huvudsak avståndet mellan lådans sidoväggar 19 och 20, medan packens höjd H motsvarar i huvudsak höjden av lådan. Med 21 betecknas ett lock som har en form vilken motsvarar lådans 15 i fig 1 öppna ovansida. I lådans hörn är

15 anslutningsstosar 22-25 anordnade. Därvid är stosarna 22 och 25 att tjäna som inlopp respektive utlopp för det ena mediet och stosarna 24 och 23 avsedda att tjäna som inlopp respektive utlopp för det andra mediet. Vid påsättningen av locket 21 med packen 12 nedlagd i lådan 15 kommer

20 locket att tätande ligga an mot packens 12 ovansida. På grund av tättningslisterna 14 och de lockbildande elementen 13 förhindras blandning av de båda medierna, då de isolerat hålles på var sin sida av packen 12 och således på var sin sida av det veckade bandet. I fig 2, vari för över-

25 skådlighetens skull den övre delen av packen är något upplyft, åskådliggöres de båda mediernas strömning. Strömningsriktningen för det ena mediet markeras med pilar 26 och det andra mediets strömning markeras med pilar 27. Såsom tydligast framgår av fig 3 kommer det omvikta

30 bandets korrugering i ett skikt att korsa korrugeringen hos nästa skikt. Dessa varandra korsande korrugeringar med mot varandra vända sidor av intill varandra belägna skikt ger en turbulens hos det medium som strömmar mellan skikten. Detta bidrager i hög grad till ett effektivt

35 värmeutbyte mellan de båda medierna.

Bandets formmönstring är vid det visade exemplet en korrugering, men man kan inom uppfinningens ram även tänka sig annan formmönstring som bildar turbulens i mellanrummet mellan skikten. Vid det visade exemplet bildas formmönstringen medelst valsar, men formmönstringen kan också tänkas ske exempelvis mellan pressdynor. Ovan har nämnts, att det lockbildande elementet 13 är utfört av ett stel-  
nande material. Det ligger emellertid även inom uppfinningens ram att utföra elementen 13 av separata lock som  
med ett mellanliggande mjukt skikt är pressat mot paketets ändar. Det är även möjligt att låta ett löst mjukt skikt ligga mellan paketets ändar och lådans gavelväggar. Lådan 15 och locket 21 bildar således ett ytterhölje som tillsammans med tätningarna 13 och 14 på paketet 12 bildar en  
effektiv avtätning mellan de båda medieströmmarna. Den på ritningarna visade avtätningen kan emellertid göras mycket enkelt och billigt. Applikationen av tätningsmassan eller annat mjukt material kräver ej någon större precision eller geometrisk noggrannhet. Eventuellt kan avtätning  
också åstadkommas genom god passform eller vid lämpligt materialval genom svetsning eller lödning.

Till skillnad från det ovan beskrivna utförandet där en låda 15 med ett lock 21 bildar ett packen 12 omgivande hölje bildas detta hölje i det i fig 4 visade exemplet av  
en i tvärsnitt rektangulär låda 28 som i sin ena sida är försedd med inlopp 29 och utlopp 30 för det ena mediet och i sin motsatta sida är försedd med inlopp 31 och utlopp 32 för det andra mediet. Packen 12 är i detta utförande  
införd från en öppen ände i lådan som således bildar en manteldel 33 som är tillslutbar medelst lock 34 och 35. Locken 34 och 35 är avsedda att i sig själva eller via mellanliggande skikt täta mot packens 12 ändar. Det i fig 4 nedre locket 34 kan t ex gjutas fast genom att fyllas med en flytande tätningsmassa som får stelna efter att det  
hopsatta paketet 28, 12 ställts ned i detsamma. Locket 35 kan sedan gjutas fast på motsvarande sätt efter det att paketet 28, 12 vänts upp och ned. Denna form av gjutning



kan även tillämpas vid det i fig 1 och 2 visade utförandet. Vid användande av lämplig tätningsmassa kan efter gjutning ifrågavarande lock eventuellt avlägsnas och tjänar därvid endast som gjutform.

- 5 Detpräglade mönstret i bandet har bl a tre uppgifter. Den ena är att åstadkomma att bandet vid veckningen bildar en konfiguration med ett visst avstånd eller delning mellan successiva veck så att medium kan strömma i de bildade mellanrummen. Präglingen skall också bidra till  
10 turbulent strömning hos mediet såsom nämnts ovan.

Det enkla mönster som beskrives ovan uppfyller båda dessa krav. Såsom nämnts ovan bildar den sneda korrugeringen efter omvikning ett system av korslagda åsar. Åsarna håller ett visst medelavstånd mellan de olika omvikningarna och ger en slingrig turbulensskapande strömningssvåg för mediet som, såsom nämnts ovan, ger god värmeöverföring till väggen.

- Genom värmeväxlarens konstruktion fördelas de två mediaflödena över ett antal parallella kanaler som ligger  
20 ömsvis inflikade mellan varandra. Den tredje uppgiften hos det präglade mönstret är att åstadkomma en fördelning av mediaflödet inom varje sådan kanal, så att det fördelas jämnt över dess sidoutsträckning. Härigenom kan åstadkommas en huvudsakligen motströms flödesbild mellan de två  
25 mediaflödena trots att deras in- och utlopp inte är riktade i strömningsriktningens förlängning.

- En effektiv sådan utbredning av flödet i sidled fås om strömningsmotståndet i sidled i kanalen är mindre än strömningsmotståndet i längsled. Med den föreslagna enkla  
30 korrugeringen av bandet blir detta fallet om korrugeringens vinkel mot bandets längdriktning är mindre än  $45^\circ$ , eller annorlunda uttryckt, om korrugeringens vinkel mot den avsedda strömningsriktningen är mer än  $45^\circ$ .

- Den enkla korrugering som tagits som exempel ovan är  
35 enkel att åstadkomma mellan två spiralskurna valsar såsom i fig 1. Den kan också väl uppfylla de önskemål om distanshållning, turbulensbildning och strömningsfördel-

7

ning som behandlats ovan. Många andra präglingsmönster är emellertid också tänkbara, såsom nämnts ovan. För att för- enkla veckningen av bandet kan korrugeringen med fördel avbrytas och ersättas av vikningsanvisningar med lämpliga mellanrum såsom visas fig 1. En annan förbättring av mönstret skulle kunna vara att mönstra in- och utlopps- delarna (bandets ytterdelar) annorlunda än huvuddelen av bandytan för att ge en ordentlig sidledsfördelning av flödena utan att strömningsmotståndet i längsled blir för stort i huvuddelen av värmeväxlaren. En minskning av strömningsmotståndet i den värmeöverförande delen av värmeväxlaren betyder emellertid oftast en minskning av värmeöverföringen där, vilket inte är önskvärt.

Uppfinningen är ej begränsad till ovan nämnda ut- föranden utan kan varieras till sina detaljer inom ramen för efterföljande patentkrav utan att uppfinningens grund- tanke därmed frångås.

20

25

30

35

**PATENTKRAV**

1. Rekuperativ värmeväxlare för värmeväxling mellan  
5 två medier via en värmeöverförande vägg, k ä n n e -  
t e c k n a d därav, att:

a) den medieåtskiljande och värmeöverförande väggen  
består av ett formmönstrat band, som är omvikt ett antal  
gångar till bildande av en flerskiktad packe, vilken är  
10 innesluten i ett ytterhölje (15, 21; 28, 34, 35);

b) bandet genom sin formning efter omvikningen bildar  
en packe (10, 12) av ömsvisa strömningskanaler med ström-  
ningsanslutning (22-25; 29-32) för de två medierna vid  
packens relativt varandra motsatta sidor; och

15 c) bandet är avtätat mot ytterhöljet i botten och  
topp av packen (12) samt i packens ändar så att läckage  
mellan medierna förhindras.

2. Värmeväxlare enligt patentkrav 1, k ä n n e -  
t e c k n a d därav, att bandets mönstring är en korru-  
20 gering i sned vinkel mot bandets längdriktning.

3. Värmeväxlare enligt patentkrav 2, k ä n n e -  
t e c k n a d därav, att bandets korrugering med lämpliga  
mellanrum är avbruten och ersatt med vikanvisningar (9)  
som underlättar omvikning av bandet.

25 4. Värmeväxlare enligt patentkrav 2 eller 3, k ä n -  
n e t e c k n a d därav, att vinkeln hos korrugeringen är  
mindre än 45° mot bandets längdriktning.

5. Värmeväxlare enligt något av föregående patent-  
krav, k ä n n e t e c k n a d därav, att bandets mön-  
30 string är sådan, att strömningsmotsståndet mot band-  
packens ändar blir högre i den tilltänkta strömningsrikt-  
ningen än tvärs denna, medan strömningsmotsståndet vid  
bandpackens mittdel är liten i den tilltänkta strömnings-  
riktningen.

35 6. Värmeväxlare enligt något av föregående patent-  
krav, k ä n n e t e c k n a d därav, att tätningen i  
packens ändar sammanfaller med två relativt varandra mot-  
stående sidoväggar av höljet.

7. Sätt att framställa en rekuperativ värmeväxlare för värmeväxling mellan två medier via en värmeöverförande vägg, k ä n n e t e c k n a t därav, att:

5 a) ett formmönstrat band (1) av värmeöverförande material omvikes ett antal gånger till bildande av en flerskiktad packe, vilken inneslutes i ett ytterhölje (20, 21; 28, 34, 35);

10 b) bandets längsgående, dvs relativt dess vikningskanter vinkelräta kanter i packen avtätas med ett lockbildande element (12);

15 c) den av det omvikta bandet bildade packen (12) inneslutes i ett hölje och med dess botten och topp avtätas mot höljet så, att bandets relativt varandra motsatta sidor är vända mot från varandra avskilda utrymmen i höljet, vilka är försedda med var sina till- och utlopp för var sitt av sagda två medier.

20 8. Sätt enligt patentkrav 7, k ä n n e t e c k n a t därav, att formmönstringen av bandet (1) utföres genom prägling under kontinuerlig frammatning mellan åtminstone två formvalsar (2, 3) som är försedda med präglingsutsprång och -fördjupningar (5, 6) motsvarande formen av önskad mönstring på bandet och eventuellt också lister (7) och fördjupningar (8) avsedda att bilda vikanvisningar i bandet.

25 9. Sätt enligt patentkrav 7 eller 8, k ä n n e t e c k n a t därav, att ifrågavarande lockbildande element åstadkommes genom gjutning av stelnde massa.

**SAMMANDRAG**

Uppfinningen avser en rekuperativ värmeväxlare för  
5 värmeväxling mellan två medier via en värmeöverförande  
vägg.

Enligt uppfinningen består den medieåtskiljande och  
värmeöverförande väggen av ett formmönstrat band som är  
omvikt ett antal gånger till bildande av en flerskiktad  
10 packe (12), vilken är innesluten i ett ytterhölje (15,  
21), varvid bandet genom sin formning efter omvikningen  
bildar en packe av ömsvisa strömningskanaler med ström-  
ningsanslutning (22-25) för de två medierna vid packens  
relativt varandra motsatta sidor, och bandet är avtätat  
15 mot ytterhöljet i botten och toppen av packen samt i  
packens ändar så att läckage mellan medierna förhindras.

Uppfinningen avser också ett sätt att framställa en  
dylik värmeväxlare.

20

(Fig 1)

25

30

35

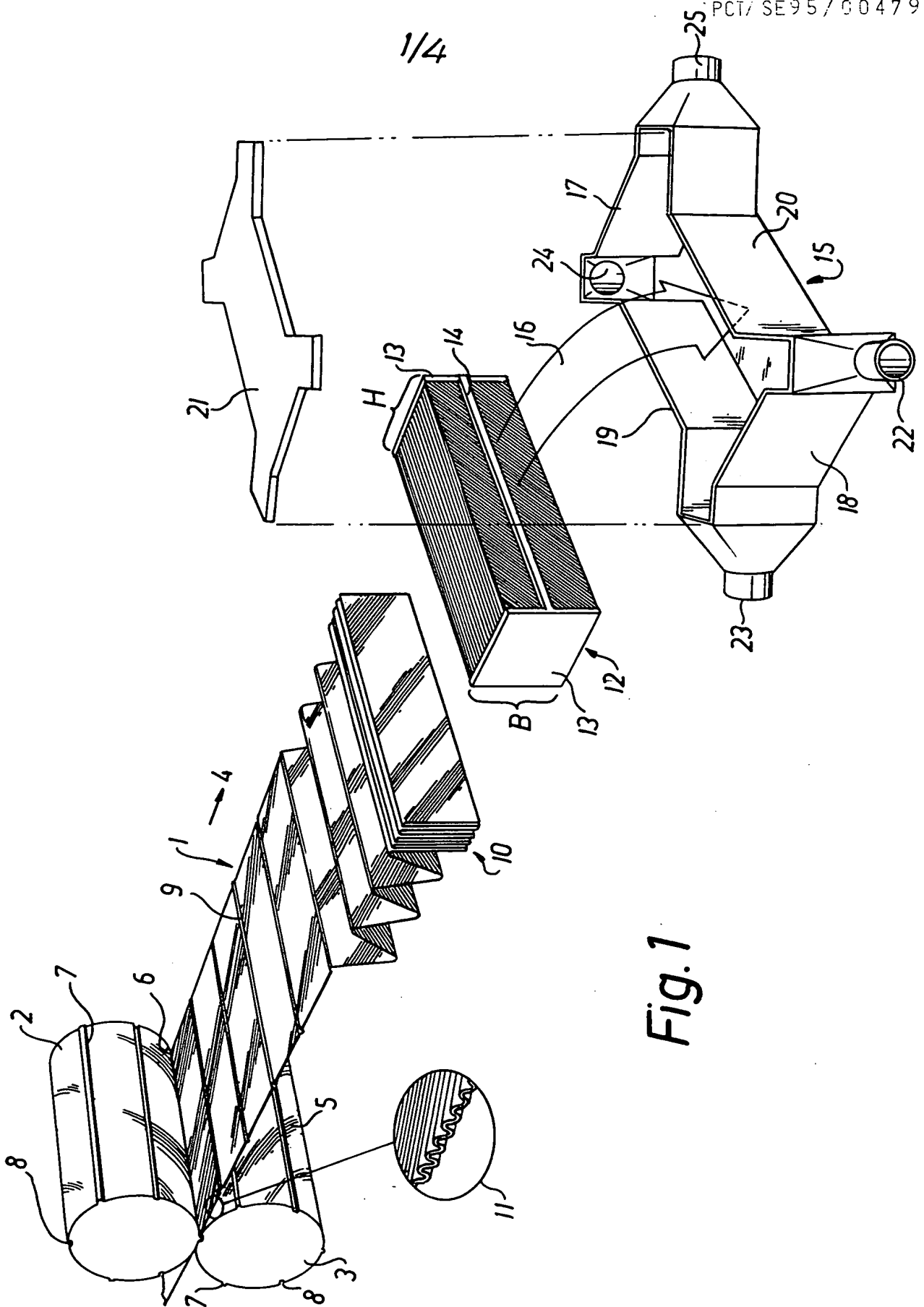
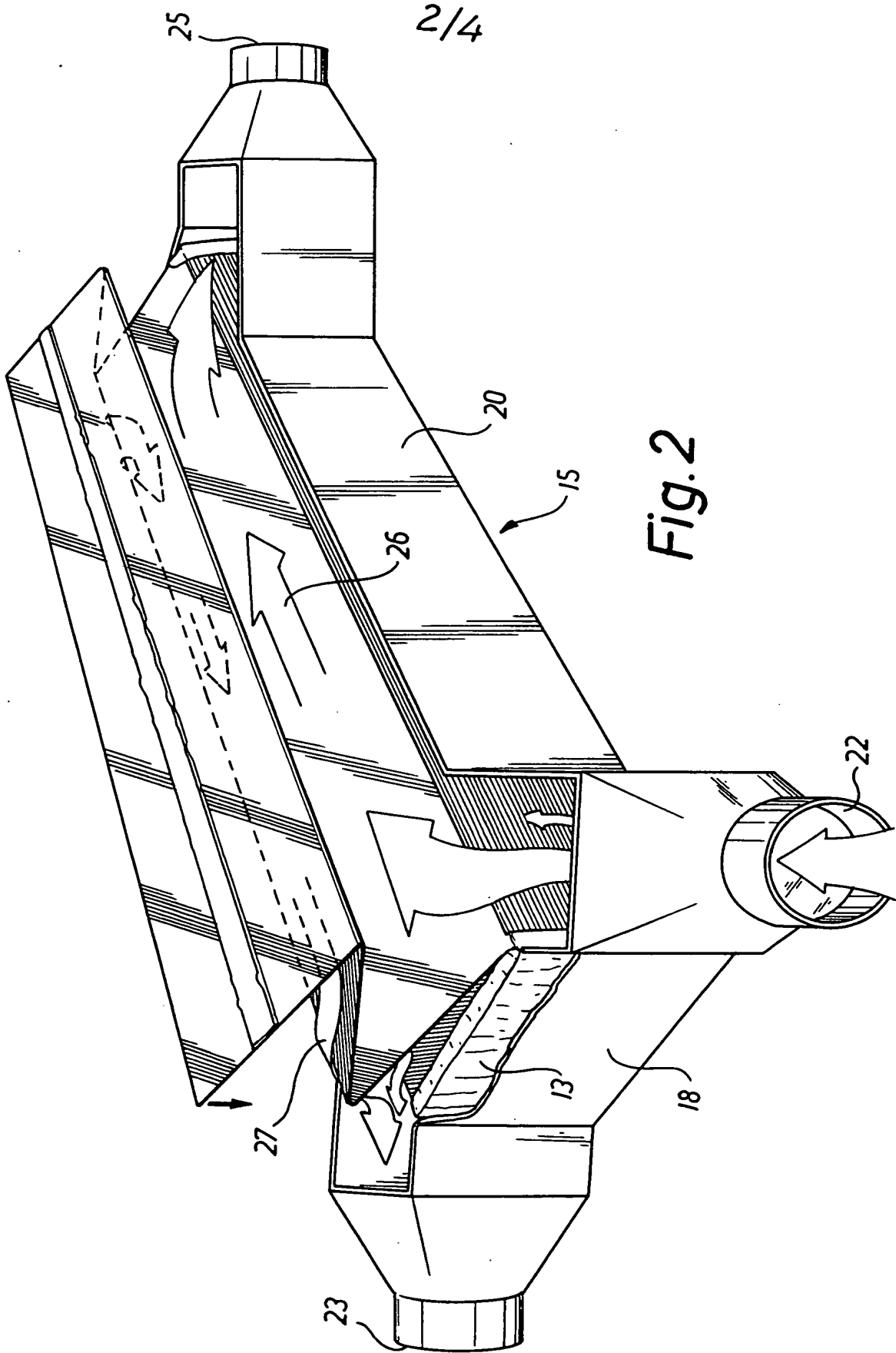
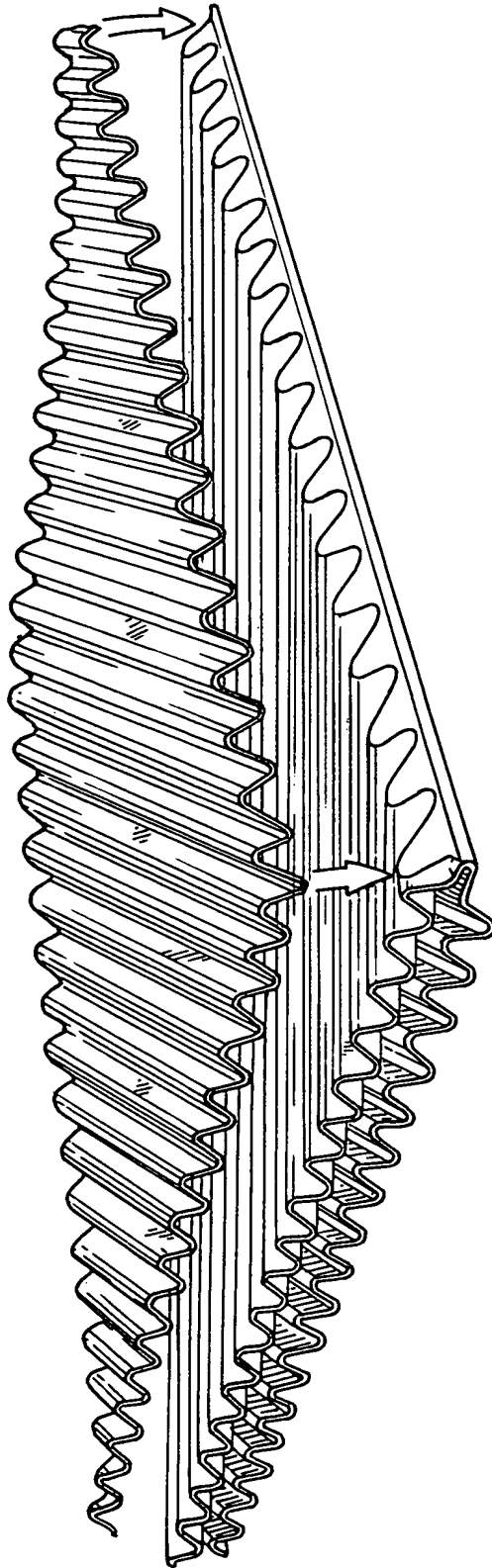


Fig. 1



3/4

Fig. 3





4/4

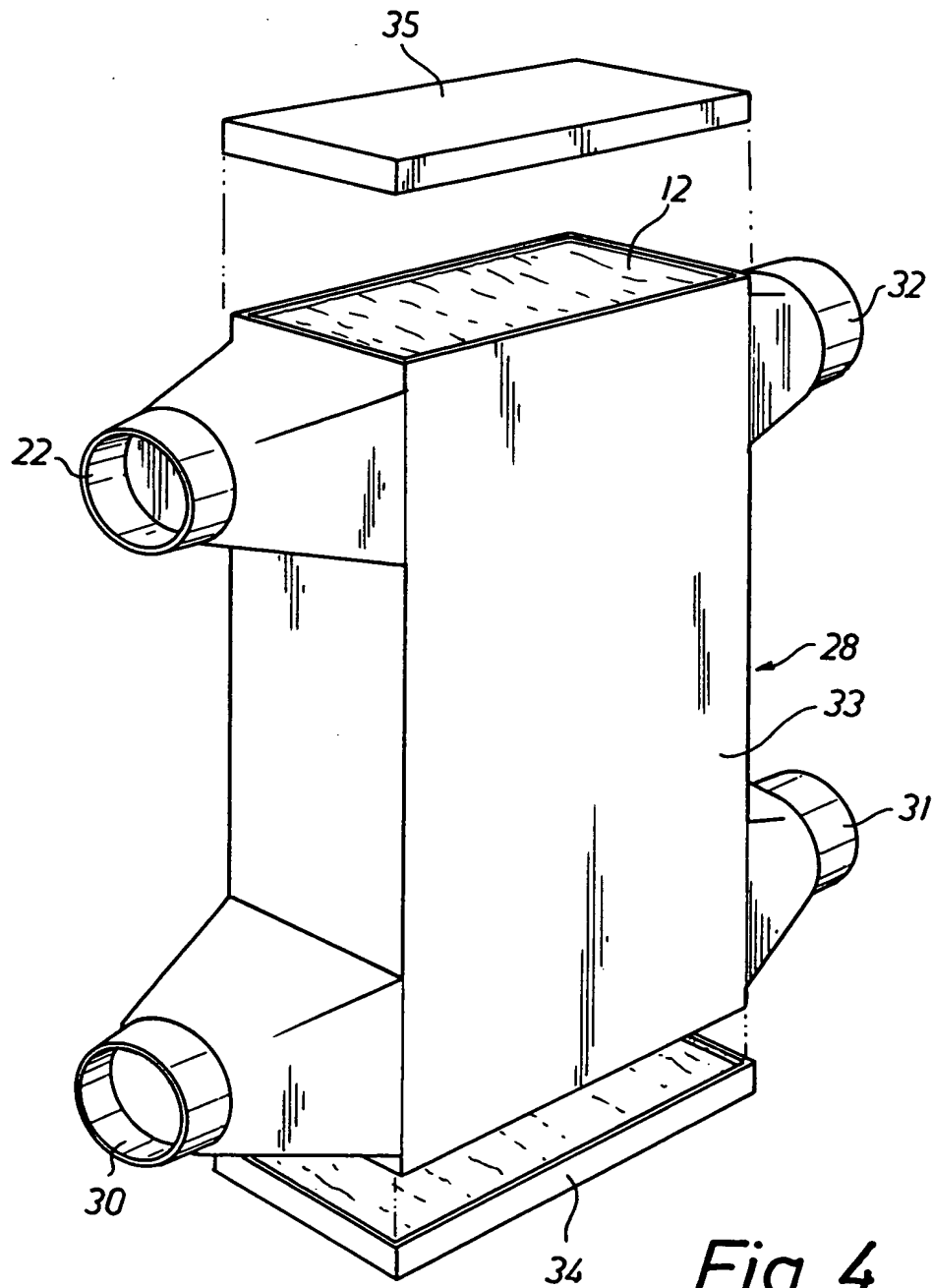


Fig. 4